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Effects of health expenditures on infant and child mortality rates: A dynamic panel data analysis of 37 African countries

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Abstract

This paper examines the effect of public and private health spending on health outcomes measured by infant and child mortality rate using a panel of 37 African countries over the period 1995–2018. Based on both system generalized method of moments and least squared dummy variable corrected bias estimators, we find that the level of public health expenditures has statistically significant positive effects on mortality reduction. However, private health spending has a statistically significant positive effect on infant and child mortality rates when it interacts with public health spending. This means that the health effect of private health expenditure is strengthened by public health spending. Conditioning on the level of private health expenditure, the total effect of public health expenditure on child mortality reduction is slightly higher in absolute value than that of private health expenditure. The main policy implication that emerges from our results is the need to increase public health expenditure and support the effectiveness of private health expenditure. This additional fund should be allocated to some specific expenditure categories which have a very direct link with child and infant mortality rates.

KEYWORDS

Africa, dynamic panel model, health expenditures, health outcomes

1 | INTRODUCTION

Health is an important form of human capital that plays a fundamental role in economic growth and poverty alleviation (Grossman, 1972; Nonvignon et al., 2015). Therefore, countries invest in their health systems to improve the health status of their population, particularly the health outcomes of mothers and children. There is a consensus among international agencies that developing countries have made efforts to achieve a reduction in child deaths and improve maternal health (World Health Organization, 2020).

Despite these improvements in health status in recent years, Africa still lags behind the rest of the world. For instance, over the period 1995–2018, the average infant and child mortality rates were 73 and 115‰, respectively, compared with the world averages 42 and 58‰, respectively (World Bank, 2020). Over the same period, the total health spending per capita increased in African countries from US$101.70 to 198.74. Although public health spending increased, a large share of the health expenditure is financed through the private sector, out-of-pocket expenditure being the highest component (World Health Organization, 2020).

Empirical results of studies on the effects of health investments on health outcomes, such as infant and child mortality, are mixed, casting some doubt on the effects of public expenditure in the health sector (Byaro, 2021; Gallet & Doucouliagos, 2017; Obrizan & Wehby, 2018). Indeed, these findings vary with different datasets and methods used especially for infant and maternal mortality rates (Owusu et al., 2021). According to Byaro (2021), most of the works focusing on African economies have used random/fixed effects estimators which produce inaccurate estimates owing to endogeneity issues (omitted variable bias, reverse causality, etc.) arising between health and its determinants. Therefore, Byaro (2021) argues that future studies on health care consumption (i.e. health expenditure) vs. health status should use a dynamic panel (i.e., system generalized method of moments, GMM) to control endogeneity issues among health and its determinants. Among a few exceptions that use a system GMM estimator are Akinlo and Sulola (2019) and Chireshe and Ocran (2020).

This paper examines the effects of public and private expenditures on health outcomes measured by infant and child mortality rates in African economies based on Grossman's (1972) theoretical model of the demand for health. This is an interesting topic because understanding the relationship between public and private health spending and health status is crutial to design and implement policies to improve the poor health condition of the population in Africa. Policymakers and practitioners can use the findings from this study in their search for cost-effective mechanisms for providing health services and the reallocation of health resources in such a manner that the gains from health spending can be optimized. Indeed, more accurate estimates of the elasticity of health outcomes with respect to health care spending can allow policymakers to use particular forms of spending to maximize the health status of the population. In contrast to most previous studies on African countries that link health care consumption to health status, we account for the dynamics of health as suggested by Grossman (1972) using the dynamic system GMM estimator to control endogeneity and its omitted variable bias. Our paper differs from the previous studies in three ways. First, we perform recent panel unit-root tests with cross-country dependence as in Pesaran (2007) and cointegration tests. Given that variables are integrated of order one but not cointegrated, we use averages over years to decrease the influence of short-run fluctuations in infant and child mortality rates and related variables, measurement error and business cycles (Bond et al., 2001; Bonnefond, 2014). As the system GMM estimator assumes the stationarity of the variables, using average data is a way to avoid the problem of non-stationarity, which could produce biased results (Bonnefond, 2014). Second, in contrast to Akinlo and Sulola (2019) and Chireshe and Ocran (2020), who compared fixed effect/random effect model results with system GMM results, we compared the findings derived from the system GMM estimator with those obtained from the least squared dummy variable corrected bias (LSDVC), which is more suitable for a dynamic panel model with a small number of cross-section unity and small T (Bruno, 2005). Therefore, the coefficients estimated and the derived conclusions will be more accurate compared with the previous ones. Third, we go beyond previous studies that have just tested the complementarity between public and private health expenditures in reducing mortality by showing conditioning on private health expenditure level, how total change in health status behaves for a percentage change in public health expenditure and vice versa.

The rest of the paper is organized as follows. Section 2 provides a literature review on the health effects of health expenditure. In Section 3, we present the empirical methodology and the data used in the empirical estimation. Section 4 presents our main findings. Finally, Section 5 provides a discussion and policy implications.

2 | LITERATURE REVIEW

A number of studies have investigated the relationships between health expenditure and health outcomes using different measures of health status such as life expectancy and infant and child mortality (Baltagi & Moscone, 2010; Barenberg et al., 2017; Gallet & Doucouliagos, 2017; Linden & Ray, 2017; Nixon & Ulmann, 2006). For developing countries such as those in Africa, infant mortality and under-5 mortality rates are considered to be a flash indicator of the health conditions because data on these indicators are more reliable than other indicators such as life expectancy and maternal mortality (Bokhari et al., 2007; Mishra & Newhouse, 2009; Obrizan & Wehby, 2018).

Previous studies on the topic are diverse with regard to the countries studied, econometric modelings and the types of health expenditures used. Using the health production function approach, researchers regressed health outcomes on health expenditure while controlling for other determinants such as gross domestic product, nutrition, age structure of the population and environmental variables. In general, health expenditures are found to have significant effects on health outcomes (Anyanwu & Erhijakpor, 2009; Gupta et al., 2002), but some studies show insignificant or small effects of health spending on health outcomes (Filmer & Pritchett, 1999; Gupta et al., 2002; Musgrove, 1996).

More recently, some studies have compared the health effects of public and private health spending but their findings are conflicting. For instance, Nonvignon et al. (2012) used panel data from 1995 to 2010 covering 44 sub-Saharan African countries, with fixed and random effects models. The authors showed that a 1% increase in both public and private health expenditures significantly increases life expectancy at birth by about 1 and 0.4–0.5 years, respectively. Similar results were found for death rates and infant mortality rates. Using a similar method on a sample of 40 sub-Saharan African countries, Arthur and Oaikhenan (2017) suggested that public health expenditure causes a statistically significant reduction on mortality rates, which is not the case for private health expenditure. However, their results suggested a significant influence of private health expenditure on life expectancy at birth. In the same vein, Kiross et al. (2020) used a random effects model for 46 sub-Saharan African countries, over the period 2000–2015. They concluded that public and external health care spending reduces infant and neonatal mortality but the effect of private health expenditure is not significant. Assessing the findings of Kiross et al. (2020), Byaro (2021) argues that future studies on health effects of health expenditures must use a dynamic panel to control endogeneity issues among health and its determinants. In the same vein, Owusu et al. (2021) used a panel of 177 countries over the period 2000–2015, and a quantile estimation method with a bootstrapping technique to control for heterogeneous parameters across countries and quantiles. The authors find that health expenditures reduce infant and maternal mortality. Crémieux et al. (2005) followed fixed effects regression methods but used Canadian province data over the period 1975–1998. They found that the effect of public health spending is larger than that of private expenditure on drugs. Furthermore, their results showed that drug spending has a greater impact on health outcomes than non-drug spending. Using a time series modeling method in which public and private expenditures predict life expectancy, together with gross domestic product (GDP) and new molecular drug approvals and data from the USA over the period 1960–2001, Lichtenberg (2004) showed that public expenditure's short- and long-run effects are positive and statistically significant but the effects of private expenditure are not clear. Linden and Ray (2017) used the panel vector autoregressive model and impulse response analysis for 34 Organisation for Economic Co-operation and Development countries over the period 1970–2012. The authors grouped these countries in three clusters, depending on the level of public health spending as a share of GDP, using the *K*-mean cluster method. The findings suggested that, in countries with the highest share of public health spending in GDP, private and public health expenditures have similar positive effects on life expectancy. However, in the countries with a small share of public health spending in the GDP, the effects of private health expenditure turn out to be negative. For their part, Ray and Linden (2019) compared the effect of public and private health expenditures on health outcomes for 195 countries over the years 1995–2014 using a new dynamic panel estimator. Dividing the countries according to growth in life expectancy, decrease in infant mortality rate and level of gross national income per capita, they found that public health expenditures are more health-promoting than private expenditures. Contrary to previous authors, Leigh and Jencks (2007) and Caliskan (2009) did not find significant differences in public and private spending effect on health outcomes.

The studies reviewed in this paper reveal the unresolved nature of the issue concerning the effects of health spending on health outcomes.

3 | MODEL, DATA, AND ESTIMATION PROCEDURES

3.1 | Model

The economic model used here is based on Grossman's (1972) model of the demand for health. The model considers economic, social and environmental factors as inputs of the production system. Based on this framework, we specified an aggregate health production function that assumes that a country's health outcomes depend on income per capita, health expenditure and a vector of socioeconomics status. We then applied an econometric model that account for the health status dynamic. With respect to the specification of a functional form, logarithms are only used in the case of health expenditure and income because the remaining variables are expressed as a percentage. Thus, the following dynamic panel data models with fixed effects are specified:

$$hs_{it} = \alpha_0 + \alpha_1 hs_{it-1} + \alpha_2 \ln\,(hexp)_{it} + \sum_k \alpha_3^k X_{it}^k + \mu_i + \lambda_t + \varepsilon_{it}, \tag{1}$$

$$hs_{it} = \delta_0 + \delta_1 hs_{it-1} + \delta_2 \ln\,(puhexp)_{it} + \delta_3 \ln\,(prhexp)_{it} + \sum_k \delta_4^k X_{it}^k + \mu_i + \lambda_t + \varepsilon_{it}, \tag{2}$$

$$hs_{it} = \xi_0 + \xi_1 hs_{it-1} + \xi_2 \ln(puhexp)_{it} + \xi_3 \ln(prhexp)_{it} + \xi_4 \left[\ln(puhexp) \times \ln(prhexp)\right]_{it} + \sum_k \xi_5^k X_{it-1}^k + \mu_i + \lambda_t + \varepsilon_{it}, \tag{3}$$

where

- hs is a vector of health outcomes (e.g., infant and child mortality rates);
- hs_{it-1} stands for one period lagged of health outcomes that captures the dynamic of health status and α_1, δ_1, and ξ_1 measure the size of the adjustment or persistence of hs_{it}. If they are close to but below 1, the past variable values can still have large effects on the current level of health status.
- $hexp$ is the total per capita health expenditure which helps measure the amount of investment in health as human capital. Its effect on health outcomes depends on the distribution between public and private health expenditures. We expect that an increase in overall medical care spending has direct positive effects on health outcome.
- $prhexp$ and $puhexp$ represent per capita private health expenditure and per capita public health expenditure, respectively. The public expenditures are used to ensure the optimal level of production and consumption of public health activities that may be extremely effective in improving health outcome (Musgrove, 1996; Ray & Linden, 2019). Thus, we expect that, if appropriately utilized, more public health expenditure should positively affect health outcomes. The effect of private health expenditure on health outcomes depends on the distribution between private insurance and out-of-pocket expenditure. If out-of-pocket health expenditure is dominant and the private health care market fails, one could expect a negative effect of private health expenditure on health outcome.
- $\ln(prhexp) \times \ln(puhexp)$ denotes the interaction between private and public expenditure. The public health activities affect the outcomes a private health care market would generate, providing incentives to improve the allocation of resources by the private sector. Thus, we expect a complementarity effect between private and public health expenditures.
- X_{it} is a vector of control variables that includes socioeconomic variables (e.g. income, education), relevant social factors (e.g. demographic structure of the population) and environmental variables (e.g. availability of clean water, safe sanitation, and the prevalence of diseases such as HIV). Our interest is in the sign and statistical significance of $\alpha_1, \alpha_2, \delta_1, \delta_2, \delta_3, \xi_1, \xi_2, \xi_3$ and ξ_4 in the health outcomes equation.
- μ_i a vector of time invariant differences in health outcomes across countries.
- λ_t is a vector of period dummies which captures universal time trends; the subscripts i and t denote country and time period, respectively.
- ε_{it} is the error term.

While Equation (1) captures the health effect of total health expenditure, Equation (2) captures the effect of private and public health expenditures on health outcomes separately. Equation (3) accounts for a potential nonlinearity by adding to Equation (2) the interaction terms between public and private health expenditures.

3.2 | Estimation procedures

Since our dataset includes the time period, we start by testing the cross-sectional dependence among our variables using the cross-sectional dependence test of Pesaran (2004). The results reported in Table 1 support the presence of cross-sectional dependence for the panel. Thus, we perform panel unit-root tests with cross-country dependence as in Pesaran (2007). The results indicate that all of the series are integrated of order 1 (Table 2). We then test whether the variables have a stable, long-run relationship using cointegration tests including the Kao cointegration test. Our results show that only the Kao panel data conclude on the cointegration of variables (Table 3).

Given that variables are integrated of order 1 but not cointegrated, we constructed a panel that contains 3 year averages of the data for each country because, compared with 5 year intervals, it allows us to keep a sufficient number of observations to use the time dimension of the panel data. The use of averages over years decreases the influence of short-run fluctuations in infant and child mortality rates and related variables, measurement error and business cycles (Bond et al., 2001; Bonnefond, 2014; Ding & Knight, 2011). Averages were constructed over 1995–1997, 1998–2000, 2001–2003, 2004–2006, 2007–2009, 2010–2012, 2013–2015 and 2016–2018, which makes eight periods of observation for each country. The total sample size, in that case, is 296 observations.

TABLE 1 Cross-sectional dependence tests.

Variables	CD test	p-Value
imr1	109.573	0.000
imr5	108.657	0.000
lthp	76.365	0.000
lpuhp	70.296	0.000
lprhp	55.427	0.000
lgdppccur	66.806	0.000
sanitation	48.694	0.000
water	88.509	0.000
imdpt	45.297	0.000
education	48.796	0.000
hiv	30.177	0.000
pop014	45.645	0.000
pop1564	52.995	0.000
pop65	−1.81	0.000
urbanization	112.737	0.000

Notes: Under the null hypothesis of no cross-sectional dependence, CD test ≈ $N(0,1)$. *p*-Values close to zero indicate that data are correlated across panel groups.

TABLE 2 Panel unit root test with cross-section dependence.

Variables	Level	Difference
imr1	−1.884	−1.765**
imr5	−1.765	−1.996*
lthp	−1.379	−2.531***
lpuhp	−1.941	−2.040***
lprhp	−1.255	−2.590***
lgdppccur	−1.721	−2.149**
sanitation	−0.640	−1.352*
water	−0.303	−0.576*
imdpt	−1.464	−2.917***
education	−1.332	−2.541***
hiv	−1.083	−2.014**
pop014	−0.918	−2.907***
pop1564	−1.303	−2.799***
pop65	−0.953	−2.264**
urbanization	1.879	2.913**

The test statistics are significant at ***1%, **5%, and *10% levels. The maximum lag length is taken as 3.

With hs_{it-1} as the explanatory variable, the fixed effect estimator of Equations (1)–(3) will be biased and inconsistent because $E(\mu_i/hs_{it-1}) \neq 0$ (Nickell, 1981). Therefore, we estimated our health production function equation using a two-step GMM system estimator with a correction method for the variance–covariance matrix (Blundell & Bond, 1998; Windmeijer, 2005). We followed Roodman's (2009) approach by limiting the number of lags for both the dependent and explanatory variables to 1.

TABLE 3 Kao cointegration test.

	Statistic	*p*-Value
Modified Dickey–Fuller *t*	1.6037	0.0544
Dickey–Fuller *t*	1.4424	0.0746
Augmented Dickey–Fuller *t*	−0.6545	0.2564
Unadjusted modified Dickey–Fuller *t*	3.3775	0.0004
Unadjusted Dickey–Fuller *t*	3.3778	0.0004

By differentiating Equation (3) with respect to the private health expenditure (4) and public health expenditure (5) we obtained:

$$\Delta\ health\ outcome = \%\ \Delta\ in\ public\ spending\,[\xi_2 + \xi_4 \ln(prhexp)_{it}], \tag{4}$$

$$\Delta\ health\ outcome = \%\ \Delta\ in\ private\ spending\,[\xi_3 + \xi_4 \ln(puhexp)_{it}]. \tag{5}$$

Equations (4) and (5) allow us to compute the conditional effects of public and private expenditure on health outcomes. They show how infant mortality (respect to child mortality) behaves if public health expenditure (respect to private health expenditure) increases by a certain percentage. The total effect of private health spending (with respect to public spending) on health outcomes when the model includes the interaction terms is interpreted as the absolute change in health outcome for a percentage change in health expenditure.

We later check the robustness of our results by using an LSDVC estimator that is the appropriate tool of inference in the dynamic panel model with a small number of cross-section unity and small *T* (Bruno, 2005). Next, we use log–log specification as an alternative functional form because this specification smooths the data and also allows for interpretation of the coefficients as elasticities. We also re-estimate the same health production equations using the underlying annual data.

3.3 | Data sources

We employed data from 37 African countries between 1995 and 2018. All of the data were obtained from the World Bank (2020) database. The descriptive statistics summarized in Table 4 show that over the period 1995–2018, infant and child mortality rates were higher in African countries (63.95 and 99.38‰, respectively) than the world average (nearly 41.99 and 58.42‰, respectively). Seychelles recorded the lowest infant mortality rate in recent years (nearly 13.7‰ on the study period). The average total health expenditure per capita was US$210.9, which represents 4.41% of GDP, and ranged from US$5.94 to 2,565. The average per capita public health expenditure was approximately 1.33 times higher than the average per capita private health expenditure (US$120.4 against US$90.50).

4 | RESULTS

4.1 | Two-step GMM system results

Table 4 presents estimates obtained from the two-step GMM system. The regression statistics for the GMM estimates indicate that the health production equations are well specified and fit the data relatively well. In particular, there is no second-order serial correlation in the residuals at a 1% significance level but there is evidence of a first serial correlation. The Sargan test statistic that is a joint test of identification and model specification indicates that the model is well specified with the appropriate instrument vector (*p*-value ranging from 0.114 to 0.355). The lagged one period of infant and child mortality is large and highly significant at the 1% level. Therefore, the use of system rather than difference GMM is the correct specification.

TABLE 4 Descriptive statistics of the variables over the period (1995–2018).

Variables	Mean	Standard deviation	Minimum	Maximum	*N*
Infant mortality rate (per 1000) [imr1]	63.95	27.01	11.80	144.1	888
Child mortality rate (per 1000) [imr5]	99.38	48.94	13.70	278.7	888
Real per capita health expenditure (US$ international, PPP) [thexp]	210.9	282.6	5.944	2,565	888
Real per capita private health expenditure (US$ international, PPP) [prhexp]	90.50	107.5	5.132	633.3	888
Real per capita public health expenditure (US$ international, PPP) [puhexp]	120.4	201.8	0.184	2,150	888
Per capita GDP (US$ international, PPP) [gdp]	4,778	5,785	469.1	41,249	888
Access to improved water (% of total population) [water]	37.01	26.22	1.324	100	888
Access to improved sanitation (% of total population) [sanitation]	61.68	19.67	9.426	99.18	888
Immunization, DPT (% of children aged 12–23 months) [vacdpt]	74.56	21.06	6/00	99	888
Primary school enrolment rate [Educ]	92.73	23.31	27.78	156.4	888
Prevalence of HIV, total (% of population ages 15–49) [hiv]	4.766	6.243	0.100	27	888
Population ages between 0 and 14 (% of total) [pop014]	41.32	6.211	22.81	50.26	888
Population ages 15 and 64 (% of total) [pop1564]	55.19	5.157	47.18	69.77	888
Population ages 65 and above (% of total) [pop65+]	3.489	1.227	1.932	8.316	888
Urbanization (% of total population) [urbanization]	41.07	16.46	7.211	77.78	887

Abbreviations: DPT, diphtheria-pertussis-tetanus vaccine; PPP, purchasing power parity.

Source: Author's calculations, based on World Bank (2020).

The coefficient estimates obtained from the system GMM had globally the expected negative sign and were similar for both health outcomes. For example, a one percentage increase in total health expenditure per capita within a country reduced infant mortality in the next 3 year period by 0.0299‰ and child mortality by 0.0619‰. These relationships were statistically significant at the 1% level for infant and child mortality. Moreover, an increase in public health expenditure per capita by 1% reduces infant mortality and child mortality in the next 3 year period by 0.009 and 0.0268‰, respectively. These relationships were statistically significant at the 5% conventional level. However, when estimated without the interaction term, as in the regression reported in columns 2 and 5 of Table 4, the coefficients on private health spending had the expected sign, but were not statistically significant at the 5% conventional level. When we introduced the interaction term obtained by combining the private and public health spending as additional control variables (columns 3 and 6), the coefficients on private health spendings became statistically significant at the 1% level while the interaction term had the expected negative sign and were also statistically significant at the 1% level for both infant and child mortality. This suggests that the effect of private health expenditure on mortality reduction depends on its interaction with the public health expenditure. Thus, the change in mortality for a percentage change in private health spending depends on the amount the government invests in the health sector. The estimated coefficients on the interaction term between private health expenditure and public health expenditure were −0.4381 for infant mortality and −1.025 for child mortality, and were statistically significant at the 1% level. The complementarity between the two types of services may be explained by the fact that the health services that are financed by the private market depend on what is offered by the public sector. In addition, this is consistent with the context of African countries where private and public health sectors are both large and there is a lesser crowding out effect. So private health spending responds to public health expenditure.

Turning to the coefficients on the other explanatory variables, we found that the estimated coefficients on income per capita had the expected negative sign and were highly significant at 1%. Mortality reduction is strongly associated with a country's income. The absolute change in mortality for a 1% increase in income ranges from 0.04747 to 0.05037‰ for infant mortality, and from 0.1030 to 0.1192‰ for child mortality. The estimated coefficients on the proportion of people with improved sanitation are highly significant for infant and child mortality. The estimated coefficient on the percentage of people with access to safe water was also negative and statistically significant at the 1%

level for infant mortality, but not for child mortality. Similar results were noted for the estimated coefficients on childhood immunization against DPT. The estimated coefficients on education variable were also significant at the 1% level. The estimates on the HIV prevalence were positive and highly significant at the 1% level.

4.2 | Total effects of public and private expenditures on infant and child mortality rates

The above analysis found that public and private health spending are complementary as the coefficient estimates on the interaction between private and public health expenditures were negative and statistically significant. We therefore explored the complementarity between private and public health expenditure in more detail to determine to what extent private and public health care services complement each other. We computed the total effects of public and private expenditure on infant and child mortality rates. They were computed using the coefficients $\xi_i$of columns 3 and 6 (Table 5). Evaluated at the sample mean value of private health spending, the total absolute change in mortality for a percentage change in public health expenditure was −2.19347‰ for infant mortality and −3.82821‰ for child mortality. Similarly, the total absolute change in mortality for a percentage change in private health spending computed at the sample mean of public health expenditure was −3.7595‰ for infant mortality and −2.04238‰ for child mortality. The total health effect of public health expenditure on child mortality reduction was higher in absolute value than that of private health expenditure, indicating that public health expenditures are more effective to reduce child mortality than private health expenditure. Figure 1 plots the estimates of the total health effects of private health spending (with respect to public health expenditure) with respect to the percentage change in public health expenditure (with respect to private health expenditure). Figure 1 reveals that the total health effect of public health spending decreases monotonically with private expenditure and vice versa.

4.3 | Robustness analysis

Table 6 reports the LSDVC coefficients estimates. The coefficient estimates here confirm to some extent the findings from the system GMM analysis. For instance, our LSDVC coefficient estimates show high persistence in the infant and child mortality rates series. Moreover, columns 3 and 6 of Table 6 suggest that public and private health spending has statistically significant effects on mortality rate when the interaction term is added as a regressor. In contrast to the system GMM results, most of the estimated coefficients on the other control variables are statistically significant at the conventional level of 5% except that on income variable. This may be due to the fact that the income variable may be endogenous because of reverse causality between income and mortality rate. However, the LSDVC estimator assumes exogeneity of the regressors, and cannot treat endogeneity issues.

The results of the estimations of health production function using the annual series show that the estimated coefficients here were slightly less statistically significant compared with the coefficients obtained from the compressed data (available upon request). However, the size of the estimated coefficients on health expenditure obtained for the annual data were slightly lower than those derived from 3 year data. These differences in the magnitude of the estimated coefficients may also be explained by the fact that, with yearly data, the influence of temporary factors associated with business cycles is not alleviated.

The results from the log–log specification suggest that main results are not sensitive to changing to log–log specification (available upon request).

5 | DISCUSSION AND POLICY IMPLICATIONS

This study showed that public health expenditure reduces infant and child mortality rates. Therefore, increased investment in public health in African countries will enhance health status. Moreover, the effect of private health expenditure on mortality reduction depends on its interaction with the public health expenditure, thus the amount the government invests in the health sector.

Our findings are not in conflict with some previous studies found in the literature, and can be added to the previous results that found a beneficial effect of health spending on mortality reduction. However, it is worth noting that the

TABLE 5 The estimated effect of health expenditure on infant and child mortality rates: 1995–2018, system GMM.

System GMM						
	Infant mortality rate (per 1000)			Child mortality rate (per 1000)		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Lagged mortality	0.831***	0.836***	0.843***	0.787***	0.805***	0.805***
	(0.0141)	(0.0146)	(0.0139)	(0.0178)	(0.0165)	(0.0198)
Log total health spending	−2.984***			−6.197***		
	(0.529)			(1.192)		
Log public health spending		−0.900**	−0.4341**		−2.628***	−0.3560**
		(0.414)	(0.1761)		(0.901)	(0.0981)
Log private health spending		−0.452	−2.106***		−2.895*	−1.987***
		(0.916)	(0.367)		(1.674)	(0.4031)
Interaction term			−0.4382***			−1.025***
			(0.0762)			(0.329)
Log gdpp	−5.307***	−4.905***	−4.747***	−11.92***	−10.37***	−11.30***
	(0.912)	(1.405)	(1.118)	(2.273)	(2.202)	(2.108)
Access to sanitation	−0.188***	−0.175***	−0.167***	−0.410***	−0.381***	−0.348***
	(0.0187)	(0.0168)	(0.0242)	(0.0413)	(0.0411)	(0.0355)
Access to water	−0.114***	−0.124***	−0.121***	−0.0930	−0.110	−0.0956
	(0.0310)	(0.0304)	(0.0298)	(0.0700)	(0.0824)	(0.0689)
Immunization against DPT	−0.0567	−0.0487	−0.0106	−0.184**	−0.176*	−0.164*
	(0.0362)	(0.0391)	(0.0413)	(0.0735)	(0.0927)	(0.0928)
Primary schcool enrolment	−0.0608***	−0.0583***	−0.0674***	−0.0882***	−0.0726***	−0.0792***
	(0.0116)	(0.0120)	(0.0154)	(0.0237)	(0.0198)	(0.0245)
HIV prevalence	0.304***	0.268***	0.311***	0.386***	0.362***	0.556***
	(0.0567)	(0.0694)	(0.0579)	(0.0807)	(0.0814)	(0.109)
Population aged 0–14	−1.125	−0.530	−1.235**	−2.045*	−2.079*	−2.469*
	(0.708)	(0.650)	(0.527)	(1.123)	(1.097)	(1.389)
Population aged 15–64	−1.266*	−0.639	−1.431**	−2.248*	−2.336**	−2.815**
	(0.749)	(0.675)	(0.572)	(1.197)	(1.110)	(1.413)
Population aged 65+	1.340	1.607**	1.094	4.079***	3.518**	3.884**
	(0.858)	(0.776)	(0.690)	(1.340)	(1.658)	(1.714)
Urbanization	−0.0952***	−0.0984*	−0.0711	−0.226***	−0.170**	−0.129*
	(0.0346)	(0.0502)	(0.0448)	(0.0873)	(0.0797)	(0.0734)
Constant	103.7	42.89	111.6**	182.6	185.9*	206.6
	(71.74)	(65.84)	(51.93)	(117.1)	(111.7)	(142.2)
AR1 test (*p*-value)	0.004	0.004	0.002	0.003	0.004	0.002
AR2 test (*p*-value)	0.436	0.690	0.481	0.290	0.338	0.172
Number of instrument	26	29	29	26	29	29
Observations	259	259	259	259	259	259
Number of countries	37	37	37	37	37	37

Note: All variables are averages over 3 year periods (except for dummies). Dummy variables for seven of the eight years are included to allow for independent trends in health status over time. Standard errors in parentheses and ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

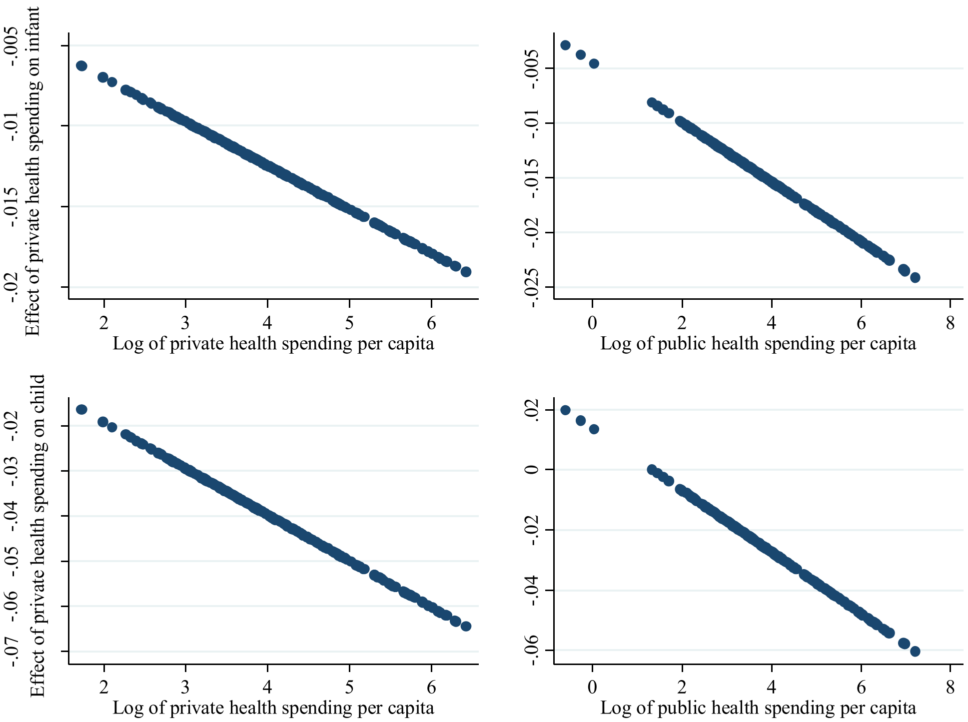

FIGURE 1 Total effects of health expenditure on infant and child mortality [Color figure can be viewed at wileyonlinelibrary.com]

computed absolute changes in infant and child mortality for a percentage change in public health spending are lower in absolute value terms compared with those obtained from previous studies. For example, Bokhari et al. (2007) found a mean elasticity of public health spending with respect to child mortality of 0.33, and Anyanwu and Erhijakpor (2009) found an elasticity of public health spending with respect to infant and child mortality that ranged from 0.7 to 0.22 and from 0.17 to 0.25, respectively. The small health impact of health expenditure may be due to several reasons. First, all categories of health expenses do not create an impact on child and infant mortality rates at the same magnitude. There is a need to categorize health expenditure to extract the categories of spending that have a direct impact on infant and child mortality rates. For instance, health expenses for maternal care, maternal clinics and mothers' nutrition may play a bigger role in determining child and infant mortality. Second, health status at low income levels depends more on factors outside the health care sector such as income and education (Musgrove, 1996; Soares, 2007). Third, health resources can be fungible or diverted as a result of corruption (Gyimah-Brempong, 2011; Rajkumar & Swaroop, 2008).

The fact that the effect of private health expenditure depends on the amount the government invests in the health sector may be linked to the failure of private health care market owing to possible mismatches between what the private health care market supplies and what fully informed and rational consumers of health care would demand. So, the gap between demand and need as well as the gap between need and supply of service may justify such an undesirable result. In addition, the composition of private health expenditure finance depends on what is offered publicly. One can also justify this result by the fact that the poor are more sensitive to the price of medical care than the non-poor, and for poorer families, increasing out of pocket expenditures may lead to catastrophic health expenditures, thereby increasing poverty, which eventually increases the infant mortality and child mortality rates. In wealthy families, the impact of private expenditure may be better because they can select from various services as they may have better access to private health insurance and they may be more informed. The opposite effect of private health expenditures on poor and wealthy families may explain the reason why private health expenditures do not have a significant direct relationship with infant and child mortality rates.

With respect to policy implications, we recommend that health policy makers increase public health spending. Increasing spending does not always improve infant and child mortality rates because of certain inefficiencies. Therefore, these additional resources must be used in high-value areas (i.e. a specific expenditure category that has a very direct link with child and infant mortality rates). Moreover, increasing public health expenditures need to be complementary with policy reform that can improve the efficiency and effectiveness of health care spending. This can ensure the usage of the allocation fund as transparently as possible and promote appropriate competition among health

TABLE 6 The estimated effect of health expenditure on infant and child mortality, 1995–2018: bias-corrected LSDV estimates.

System GMM						
	Infant mortality rate (per 1000)			Child mortality rate (per 1000)		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Lagged mortality	0.857***	0.860***	0.856***	0.862***	0.864***	0.859***
	(0.0269)	(0.0268)	(0.0263)	(0.0273)	(0.0272)	(0.0263)
Log total health spending	−0.602			−1.562		
	(0.578)			(1.189)		
Log public health spending		−0.498	−2.958***		−0.137***	−3.626**
		(0.478)	(0.509)		(0.00294)	(1.3750)
Log private health spending		0.111	−0.0650		0.352	−1.820*
		(0.534)	(0.030)		(1.109)	(0.895)
Interaction term			−0.126*			−0.786**
			(0.0451)			(0.328)
Log gdpp	0.797	0.672	0.781	2.285	1.929	2.329
	(1.006)	(1.001)	(1.020)	(2.136)	(2.118)	(2.154)
Access to sanitation	−0.109***	−0.110***	−0.108***	−0.262***	−0.263***	−0.258***
	(0.0343)	(0.0347)	(0.0340)	(0.0720)	(0.0726)	(0.0708)
Access to water	−0.207***	−0.208***	−0.192***	−0.402***	−0.399***	−0.349***
	(0.0562)	(0.0569)	(0.0623)	(0.111)	(0.113)	(0.123)
Immunization against DPT	−0.122***	−0.121***	−0.123***	−0.198**	−0.194**	−0.202***
	(0.0367)	(0.0371)	(0.0364)	(0.0774)	(0.0780)	(0.0760)
Primary schcool enrolment	−0.0487***	−0.0448***	−0.0490***	−0.0803**	−0.0705*	−0.0839**
	(0.0171)	(0.0174)	(0.0175)	(0.0357)	(0.0366)	(0.0362)
HIV prevalence	−0.0596	−0.0610	−0.0484	−0.0969	−0.0943	−0.0534
	(0.168)	(0.169)	(0.167)	(0.349)	(0.350)	(0.344)
Population aged 0–14	−0.410	−0.397	−0.459	−0.607	−0.587	−0.777
	(0.468)	(0.472)	(0.482)	(0.969)	(0.975)	(0.988)
Population aged 15–64	−0.563	−0.566	−0.640	−0.898	−0.928	−1.145
	(0.494)	(0.502)	(0.511)	(1.014)	(1.029)	(1.041)
Population aged 65+	1.141	1.195	1.361	2.163	2.371	2.916
	(0.918)	(0.928)	(0.872)	(1.972)	(1.984)	(1.846)
Urbanization	−0.326***	−0.328***	−0.301***	−0.616***	−0.622***	−0.536***
	(0.0686)	(0.0692)	(0.0775)	(0.144)	(0.145)	(0.163)
Observations	259	259	259	259	259	259
Number of countries	37	37	37	37	37	37
Significance of model	113.84***	104.35***	96.50***	102.66***	94.55***	87.72***

Notes: Bootstrap standard errors are reported under the coefficient value, The initialization is based on the Blundel and Bond estimator. The significance of the model refers to the χ^2 values for the Wald tests of joint significance of the explanatory variable coefficients.

*Significant at 10%; **significant at 5%; ***significant at 1%.

care providers, including the private health sector. Such increases also need to be accompanied by public spending in other sectors such as education, water, the road network, better quality of institutions, and so forth. Increasing public health care and its efficiency is important to make private health care spending more effective through the reduction of inefficiencies (i.e. patients received appropriate care, appropriate competition, etc.). This can significantly reduce the gap between the patient's needs and what is actually done and increase the quality of care.

Our study has a number of limitations. The dataset has a high rate of missing data for a number of potentially important predictors of infant and child mortality, such as health infrastructures, human resources and health system reforms (i.e. health insurance), which forces us to omit them from the study. Another limitation is that we allow the parameters to be the same across all countries, which is questionable. The use of other dynamic panel models (i.e. pool mean group estimator, mean group estimator and dynamic fixed effects estimator) that allow for parameter heterogeneity and correlated error terms could provide robustness tests. We leave these open issues for future research when more comprehensive data become available.

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